HYDROLOGY SPECIALIST REPORT

Sunny South Insect Treatment Project
Tahoe National Forest
American River Ranger District
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1. PURPOSE AND SCOPE

The purpose of this report is to analyze and compare the hydrologic impacts from the proposed action addressed in the Sunny South Insect Treatment Project on the American River Ranger District, Tahoe National Forest. In particular, this analysis will focus on the effects of the proposed action on watershed resources, including: watershed condition (potential for increases in erosion and sediment), disturbances within the Riparian Conservation Areas, and water quantity and quality.

The proposed action includes the following activities: (1) Mechanical thinning and removal of insect infected trees, including roadside hazard trees within treatment unit boundaries and construction of 2.7 miles of temporary road, (2) Fuels treatments include removal of non-commercial trees by whole-tree yarding to the landing, piling (by hand or grapple with tracked equipment) and burning biomass, mastication of shrubs, small trees and slash, and under burning, (3) Subsoil or rip compacted soil on approximately 9 miles (13 acres) of non-system roads and trails, landings, main skid trails and temporary roads with equipment such as a winged sub-soiler or other tilling device to a depth of 12 to 18 inches, (4) Maintenance of approximately 20 miles of existing roads to implement project activities and removal of trees within 10 feet of encroaching on system roads, and (5) In areas of concentrated mortality, reforest using a combination of site preparation, plant and release treatments. Site preparation would include tilling the top soil, as needed, to remove brush and other competing vegetation to facilitate the planting effort.

2. BACKGROUND

2.1. Guiding Laws, Regulations, Policies, and Direction

Clean Water Act of 1948 (as amended in 1972 and 1987) establishes as federal policy the control of point and non-point pollution and assigns the States the primary responsibility for control of water pollution. Compliance with the Clean Water Act by national forests in California is achieved under state law.
This project complies with the Clean Water Act through use of "Best Management Practices" designed to minimize or prevent the discharge of both point and non-point source pollutants from Forest roads, developments and activities. Under the Clean Water Act regulations, the Forest Service is required to obtain permits from the California Regional Water Quality Control Board (RWQCB). At this time, the Forest Service is working with the RWQCB to secure the appropriate permit(s) for this project.

The California Water Code consists of a comprehensive body of law that incorporates all state laws related to water, including water rights, water developments, and water quality. The laws related to water quality (sections 13000 to 13485) apply to waters on the national forests and are directed at protecting the beneficial uses of water. Of particular relevance is section 13369, which deals with nonpoint-source pollution and BMPs.

The Porter-Cologne Water-Quality Act, as amended in 2006, is included in the California Water Code. This act provides for the protection of water quality by the State Water Resources Control Board and the Regional Water Quality Control Boards, which are authorized by the U.S. Environmental Protection Agency to enforce the Clean Water Act in California.

Regional Water Quality Control Boards are the primary regulatory agencies for water quality in California. Each Regional Board has a Basin Plan that includes identified beneficial uses and water quality objectives (standards) for water bodies within each region. Basin Plans may include prohibitions of pollutant discharges, and are incorporated into the California Water Code. As such, Basin Plans are enforceable laws. Regional Boards may establish Timber Waivers that regulate vegetation management activities on national forests. Timber Waivers include conditions and requirements for reporting and monitoring.

Non-point source pollution on national forests is managed through the Regional Water Quality Management Plan (USDA Forest Service, Pacific Southwest Region, 2000), which relies on implementation of prescribed best management practices. The Water Quality Management Plan includes BMPs for timber harvesting, road building and maintenance, and protection of Riparian Conservation Areas.

Working cooperatively with the California State Water Quality Control Board, the Forest Service developed pollution control measures, referred to as Best Management Practices (BMPs) that are applicable to National Forest System lands. The BMPs were evaluated by State Water Quality Control personnel as they were applied on site during management activities. After assessment of the monitoring data and completion of public workshops and hearings, the Forest Service's BMPs were certified by the State and approved by the Environmental Protection Agency (EPA) as the most effective means to control non-point source pollution.

The land treatment measures incorporated into Forest Service BMPs evolved through research and development measures, and have been monitored and modified over several decades with the expressed purpose of improving the measures and making them more effective. On site evaluations of the control measures by State regulatory agencies found the practices were effective in protecting beneficial uses and were certifiable for Forest Service application as their means to protect water quality. The Clean Water Act provided the initial test of effectiveness of the Forest Service non-point pollution control measures by requiring evaluation of the practices by regulatory agencies (State Board and EPA) and the certification and approval of the practices as the "BEST" measures for control.

BMPs are designed to accommodate site-specific conditions. They are tailor-made to account for the complexity and physical and biological variability of the natural environment. In the 1981 Management Agency Agreement between the State Water Resources Control Board and the Forest Service the State agreed that: "The practices and procedures set forth in the Forest Service document constitute sound water quality management and, as such, are the best management practices to be implemented for water quality protection and improvement on NFS lands." Further the Water Quality Control Plan for the Central Valley Regional Water Quality Control Board states "Implementation of the BMPs, in conjunction with monitoring and performance review requirements approved by the State and Regional Boards, is the primary method of meeting the Basin Plan's water quality objectives for the activities to which the BMPs apply."

Waiver for Timber Harvest Activities

The Regional Water Quality Control Board, Central Valley Region (CVRWQCB), on 4 December 2014, adopted Order No. R5-2014-0144 (Resolution) which provides for a conditional waiver of the requirement to file a report of waste discharge and obtain waste discharge requirements for timber harvest activities on U.S. Forest Service (USFS) lands within the Central Valley Region. The eligibility criteria for obtaining a conditional waiver are listed below. This project has complied with all the “Eligibility Criteria” and “General Conditions” specified in the Regional Board’s Waiver.

To be eligible for coverage under this waiver category, the project has met the definition of timber harvest activities, and will comply with all of the applicable eligibility criteria and conditions.

Eligibility Criteria:

1. USFS has conducted a multi-disciplinary review of the timber harvest proposal, including review by watershed specialists, and has specified best management practices (BMPs), and additional control measures as needed, in order to assure compliance with applicable water quality control plans.
2. USFS has conducted a cumulative watershed effects (CWE) analysis and included specific measures needed to reduce the potential for CWEs in order to assure compliance with applicable water quality control plans.
3. USFS has allowed the public and other interested parties reasonable opportunity to comment on and/or challenge individual timber harvest proposals.

This project has complied with all the “Eligibility Criteria” and “General Conditions” specified in the Regional Board’s Waiver.

National Forest Management Act 1976

The National Forest Management Act of 1976 (NFMA) recognized the fundamental need to protect, and where appropriate improve, the quality of soil, water, and air resources. With respect to water and soils, NFMA requires that the Forest Service manage lands so as not to impair their water quality and long-term soil productivity. Further, activities must be monitored to ensure that productivity is protected. This law led to subsequent regulation and policy to execute the law at various levels of management.

The Forest Service Manual (FSM) provides agency guidance for salvage harvests and protection of riparian areas. Directives for salvage sales are included in FSM 2435. Directives for riparian area management are provided in FSM 2526, which provides that riparian areas shall be managed under the principle of multiple-use and sustained-yield, with emphasis on protection and improvement of soil, water, and vegetation. Directives for water-quality management are provided in FSM 2532, which provides that BMPs will be applied to all management activities.

2.2 MANAGEMENT DIRECTION, STANDARDS AND GUIDELINES

The Tahoe National Forest Land and Resource Management Plan (LRMP) (USDA Forest Service 1990), as amended by the Sierra Nevada Forest Plan Amendment (SNFPA) USDA Forest Service 2004), provides direction for maintaining water quality and quantity; protecting streams, lakes, wetlands, and riparian conservation areas; and to prevent excessive, cumulative watershed impacts.

Riparian Area Management
The SNFPA requires that a site-specific project-level analysis be conducted to determine whether activities proposed within Riparian Conservation Areas (RCAs) meet the Riparian Conservation Objectives (RCOs). This analysis examines how well the Proposed Action for the project meets the Riparian Conservation Objectives and/or how it would bring the project area closer to meeting these objectives.

The following goals are part of the Aquatic Management Strategy (AMS) as presented in the SNFPA Record of Decision:

1. Water Quality -- Maintain and restore water quality to meet goals of the Clean Water Act and Safe Drinking Water Act, providing water that is fishable, swimmable, and suitable for drinking after normal treatment.
2. Species Viability -- Maintain and restore habitat to support viable populations of native and desired non-native plant, invertebrate, and vertebrate riparian-dependent species. Where invasive species are adversely affecting the viability of native species, work cooperatively with appropriate State and Federal wildlife agencies to reduce impacts to native populations.
3. Plant and Animal Community Diversity -- Maintain and restore the species composition and structural diversity of plant and animal communities in riparian areas, wetlands, and meadows to provide desired habitats and ecological functions.
4. Special Habitats -- Maintain and restore the distribution and health of biotic communities in special aquatic habitats (such as springs, seeps, vernal pools, fens, bogs, and marshes) to perpetuate their unique functions and biological diversity.
5. Watershed Connectivity -- Maintain and restore spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically and biologically unobstructed movement for their survival, migration and reproduction.
6. Floodplains and Water Tables -- Maintain and restore the connections of floodplains, channels, and water tables to distribute flood flows and sustain diverse habitats.
7. Watershed Condition -- Maintain and restore soils with favorable infiltration characteristics and diverse vegetative cover to absorb and filter precipitation and to sustain favorable conditions of stream flows.
8. Streamflow Patterns and Sediment Regimes -- Maintain and restore in-stream flows sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats and keep sediment regimes as close as possible to those with which aquatic and riparian biota evolved.
9. Stream Banks and Shorelines -- Maintain and restore the physical structure and condition of stream banks and shorelines to minimize erosion and sustain desired habitat diversity.

A key element of the Aquatic Management Strategy is a set of land allocations, specifically riparian conservation areas and critical aquatic refuges, that delineate aquatic, riparian, and meadow habitats, which are to be managed consistent with the riparian conservation objectives (RCOs) and associated standards and guidelines. The RCO analysis is included in this document.

Water Quality Protection (V-35)

Use Best Management Practices (BMPs) to meet water quality objectives and maintain and improve the quality of surface water on the Forest. Methods and techniques for applying the BMPs will be identifies and documented during project level environmental assessments and incorporated into the associated project plan and implementation documents.

Current Science

The environmental consequences of implementing an action alternative are interrelated in terms of watershed condition including: riparian, aquatic, soil and water resources. Watershed effects could include changes in erosion and subsequent sediment delivery to stream channels, road related sediment delivery to channels, and water quality. The major factors that influence the amount of sediment that reaches streams include slope channel stability, distance of ground disturbance from a stream or other aquatic feature, slope of the ground surface, precipitation characteristics, percent and type of soil cover, geology, soil characteristics, and micro-topography.

Tractor harvest has the highest potential to result in ground disturbance. The harvesting of felled trees has a potential to adversely impact water quality depending on the logging system employed. Skidding of felled trees has the potential to increase soil compaction and subsequent erosion on skid trails after as few as 1-2 round trips. Not only can soil porosity be reduced but macropore space can also be reduced to the magnitude that impedes the infiltration of water increasing surface flow, resulting in surface erosion. Disturbance of hydrologic and soil processes often result in adverse effects to aquatic systems.

2.2. Methodology

2.2.1. Tools Used to Predict Impacts

The Pacific Southwest Region (R-5) of the Forest Service has developed a standardized cumulative watershed effects (CWE) analysis (FSH 2509.22) that serves as a surrogate method for determining the risk of delivering excess sediment to streams. There are two parts to CWE analysis: 1) determination of the Threshold of Concern (TOC) and 2) assignment of Equivalent Roaded Acre (ERA) coefficients to activities.

The Tahoe NF has developed a standard method for determining watershed TOC values based on several factors. Each watershed is assessed for its ability to withstand erosional processes and handle sediment delivery to stream channels. The assessment is based on climatological, geologic and soils information; on-the-ground surveys of the stream channels and upland areas; and the experience and professional judgment of current and former TNF watershed specialists. A range of TOC values from a high of 0.18 (18%) to a low of 0.09 (9%) was determined using the information from the watershed assessment, the compaction guidelines in the TNF LRMP, and literature review of research on impacts of timber harvesting activities on sediment production.

Cumulative watershed effects (CWE) are the combined effects of past, present, and future land management activities within a watershed that may affect the watershed’s structure or process. The CWE analysis considers a number of assessment methods at multiple scales. The most site-specific assessment is the individual forest assessments that assess the potential for adverse CWE by comparing the current level of watershed disturbance to an estimate of "the upper limit of watershed tolerance to externally applied factors such as climate and land use," called the Threshold of Concern (TOC). The Equivalent Roaded Acre (ERA) is used as the standardized unit of measure for land disturbance and the current level of watershed disturbance is expressed as “percent ERA”. The current “percent ERA” of a watershed is compared to the TOC to provide an assessment of CWE potential.

The TOC does not represent the exact point at which cumulative watershed effects will occur. Rather, it serves as a “yellow flag” indicator of increasing susceptibility for significant adverse cumulative effects occurring within a watershed. Susceptibility of CWE generally increases from low to high as the level of land disturbing activities increase towards or past the TOC.

2.2.2. Field Observations

The purposes of field work were to: (1) gather information on site-specific soil and hydrologic properties, (2) assess current soil and hydrologic conditions as affected by past management activities, and (3) develop predictions on cumulative watershed responses to the proposed treatments. Site observations included some reconnaissance surveys for erosion and/or sediment movement and looking at the range of existing conditions within the proposed activity areas.

Luke Rutten, Hydrologist, and Nikos Hunner, Soil Scientist made field observations in the project area winter-summer of 2016 to document field conditions.

2.3. Affected Environment

Watershed resources include riparian and aquatic habitats and water quality. Riparian and aquatic habitats within the project area include: springs/seeps, perennial streams, and seasonal streams. This report focuses on hydrologic effects (water quality, flow, erosion, etc) of the project on riparian and aquatic habitats.

The project area is located on land that drains to the North and Middle Fork American Rivers, which flow generally in a northeast to southwest direction. The primary streams in the project area include; North Shirtail Canyon, Forbes Creek and Pagge Creek in the Sugar Pine area, Volcano Creek near the Seed Orchard, and Peavine Creek near Big Oak Flat.

State-designated beneficial uses within the North and Middle Fork American River watersheds include municipal and domestic water supplies, irrigation and stock watering, hydroelectric power generation, contact and non-contact recreation, canoeing and rafting, cold freshwater fisheries spawning, and wildlife habitat (CRWQCB 2011).

The project is located within five 14-digit hydrologic units (HU) which range in size from nearly 4300 to over 6000 acres. These 14-digit HUs are nested within larger HUs as shown in table 1. Watershed condition has been assessed at the 14-digit HU for this project.

Table 1. Project Area Watershed Hierarchy.

10-digit HU Watershed	12-digit HU Subwatershed	14-digit HU "Drainages"	Acres
Lower North Fork American 1802012806			91558
	Upper Shirttail Canyon 180201280601		19772
		Upper North Shirttail Canyon 18020128060101	5912
		Lower North Shirttail Canyon 18020128060102	6053
Lower Middle Fork American 1802012805			62221
	Volcano Canyon- Middle Fork American 180201280503		21547
		Volcano Canyon 18020128050301	5060
North Fork Middle Fork American 1802012804			59106
	Peavine Creek – NFMF American 180201280403		21614
		Peavine Creek 18020128040302	5485
		NFMF American – El Dorado Canyon 18020128040304	4977

2.3.1 Riparian Conservation Areas

There are 223 acres of lakes, 279 miles of stream channels, and 11 springs within the project area. These are accompanied by 11850 acres of Riparian Conservation Areas (RCAs) and 3280 acres of riparian buffers. RCAs range in width from 300 feet on each side of perennial channel to 150 feet on intermittent and ephemerals. Within the RCAs, riparian buffers are 100 feet on each side of a perennial, 50 feet on intermittents and 25 feet on ephemerals.

Table 2. Lakes, Streams and Springs by HU14 within Project Area Drainages.

14 digit HU	Lake Acres	Ephemeral miles	Intermittent miles	Perennial miles	Springs
Upper North Shirttail Canyon 18020128060101	217.0	33.3	4.7	12.6	5
Lower North Shirttail Canyon 18020128060102	5.1	25.6	9.0	11.1	3
Volcano Canyon 18020128050301	0.5	26.7	2.7	9.9	
Peavine Creek 18020128040302	0.7	59.4	2.4	17.3	
NFMF American – El Dorado Canyon 18020128040304	0.0	48.5	3.3	12.7	3
Total	223.3	193.5	22.1	63.7	11

Table 3. Acres of RCA and Riparian Buffers within Project Area Drainages.

14 digit HU	HU Acres	Riparian Buffer Acres	Riparian Conservation Area Acres
Upper North Shirttail Canyon 18020128060101	5912	849.7	2551.2
Lower North Shirttail Canyon 18020128060102	6053	534.2	1942.7
Volcano Canyon 18020128050301	5060	430.1	1677.8
Peavine Creek 18020128040302	5485	793.7	3148.8
NFMF American – El Dorado Canyon 18020128040304	4977	672.5	2529.1
Total		3280.2	11849.6

2.3.2 Existing Condition

Upland Characteristics
Hillslopes in the project area range from gentle to steep. The uplands are dominated by conifer vegetation with a mixed understory that acts to provide ground cover to aid in erosion control. The hillslopes are mostly stable with no evidence of significant surface erosion. Due to past fires and post-fire reforestation efforts, surface fuel loads in the uplands is at or near desired condition in most areas. However, ongoing mortality of pine due to insect attack is resulting in high fuels loads in the project area. At this time most of the dead trees are standing. Over time this material will fall to the ground if it is not removed as part of this project.

Channel Characteristics
Stream channels in the project area range from steep headwater ephemerals to moderate gradient perennial channels. The characteristics of these varied channel types are defined by their position in the watershed, their underlying geology, the climate, and riparian and upland vegetation. This also drives the manner in which they process water flow and sediment in the watershed. Therefore, different stream types will tend to respond differently to temporal changes in sediment input or streamflow due to natural or human caused events.

The ephemeral streams are primarily steep headwater colluvial channels (Montgomery and Buffington 1997). These channels are narrow and shallow and are sometimes hard to define on the ground due to their headwater location. They experience highly sporadic fluctuations in runoff and accumulate sediment from the hillslope over long time periods (decades to centuries). They then flush such sediment downstream during infrequent high runoff events or debris flows (Montgomery and Buffington 1997). Such channels are described as transport-limited and respond to changes in sediment supply by fluctuating the amount of sediment in storage and changes in runoff by changing the frequency of sediment flushing events.

Downstream of the colluvial headwater streams are steep bedrock, cascade and step-pool channels (Montgomery and Buffington 1997). They are high gradient, high-energy, supply-limited systems; in the sense that they exhibit a high capacity to transport sediment relative to sediment supply. Therefore, these channels are able to withstand temporal increases in sediment supply and efficiently transport such supply increases through the system

(Montgomery and Buffington 1997). Also, these channels are often stable enough to withstand large flood events or periods of low sediment input.

The perennial streams alternate between low gradient pool-riffle and steeper bedrock or step-pool segments. The steep sections follow the descriptions above for the tributaries. The low gradient segments are relatively lower energy than steep segments and therefore have a lower sediment transport capacity relative to supply. This results in these low gradient segments being more sensitive to changes in sediment supply or streamflow. Increased supply or decreased runoff can result in detrimental sediment deposition while decreased supply or increased runoff can cause erosion and the streambed and banks (Montgomery and Buffington 1997).

Overall, channel segments in the project area appear stable with localized evidence of excessive erosion or deposition of sediment. Several stream reaches are downcut and incised by 2-4 feet. These areas of instability and incision can be traced to past impacts of mining, fire and post-fire reforestation efforts and roads or ongoing impacts from roads. Several of the roads in the project area are routing sediment directly to the channels. Where feasible, these issues will be addressed by the project.

Fuel loading in the riparian zones is higher than desired in most of the project area. This is due to several factors including fire suppression and lack of treatment. Over the past several decades active treatment of vegetation and fuels within riparian zones has been limited or excluded in order to protect these areas from disturbance. The result of this management approach is the current high fuels loads. These areas are now more susceptible to unnaturally severe burning, which means when these areas do experience fire in the future, the impacts to the riparian zone, stream channels and water quality conditions will be much greater than they would be under more natural conditions. This situation is common throughout the Sierra Nevada as shown by the research of Van de Water and North (2010, 2011). Therefore, active treatment of fuels within the riparian zones is critical within this project to protect these areas from impacts of future high severity fire.

3. ENVIRONMENTAL EFFECTS

3.1 Bounding Of Effects Analysis

For watershed resource assessment, the spatial analysis is bounded by the five 14 digit HU drainages that have the potential to be impacted directly, indirectly or cumulatively by the proposed activity. These are listed in table 1. The temporal boundary is approximately ten years for past projects and any known, foreseeable projects that have enough detail to reasonably analyze in the CWE analysis and that would contribute to effects of proposed actions.

3.2 Management Requirements

Management requirements are prescriptive measures that are designed to prevent adverse effects upon the soil and water resource, rather than traditional mitigation which aims to resolve the problem once it has occurred. Management requirements incorporated into the proposed action are designed to reduce the risk of accelerated erosion and sedimentation adversely impacting aquatic and riparian habitats due to the proposed action activities. Some management requirements incorporate mitigation measures to be conducted in conjunction with operations for treating unavoidable adverse effects. These measures have been effectively used on many projects on the Tahoe National Forest and on other National Forests in California and are listed in the project decision memo.

3.3 Direct and Indirect Effects of Proposed Action

Forest management activities have the potential to affect the hydrologic, soil, and aquatic resources by causing soil disturbance, altering vegetative cover, and changing local drainage patterns. The effects of the proposed management activities are most closely related to the harvesting and reforestation techniques used. Ground-based mechanical systems have the highest potential impacts. Applying the Forest Plan Standards and Guidelines and effective Best Management Practices (BMPs) reduce the magnitude of the effects to soil, water, and aquatic resources. In addition, management requirements were developed to avoid sensitive watershed areas or minimize soil/water/aquatic concerns. The primary concern to water quality is the impairment of beneficial uses due to an increase of fine sediment caused by accelerated erosion from the proposed projects. The risk of direct effects to forest soils, water quality, and aquatic species would be low, because project design minimizes activities that might otherwise have an impact to these resources.

Effectiveness of the BMPs in mitigating direct and indirect effects is largely related to proper implementation and the magnitude of climatic events the first several seasons after project completion. There is a risk that heavy precipitation or rain on accumulations of snow could overwhelm erosion control structures and render them ineffective. The increased sediment delivery to channels would occur only during rare events and for short periods of time where overland flow from disturbed areas occurs. BMPs have been selected using specific information regarding soil, slope, geology, and climate conditions typically found in the project area.

The following section describes the effects of the proposed project in terms of direct and indirect effects.

3.3.1 Thinning and removal of insect infested trees, including roadside hazard trees.

Erosion, sediment and water quality

Mechanical thinning involves the use of mechanical, ground-based equipment and cable harvesting equipment. Mechanical harvest with ground-based equipment would be conducted on slopes generally less than 35 percent. Limited operations on steeper slopes will be identified in consultation with a watershed specialist and the timber sale administrator on a site by site basis. Ground-based thinning and removal of insect infested trees will occur on 2455 acres. Unit SP-27 is a ground-based thinning unit with cable yarding. Logs would be bunched where needed with tractors and hauled to 4 or 5 cable corridors for yarding uphill to existing landings.

The potential direct effects of mechanical, ground-based equipment on soils include a reduction in soil cover; an increase in compaction due to the building of temporary roads, and reopening of existing roads, skid trails, and landings; soil displacement during skidding operations; and a loss of nutrients and organic material through removal of small material, such as tree tops and limbs. The potential direct effects of the harvest on hydrology and water quality would depend on how much ground is detrimentally compacted, how much cover is removed, steepness of the treated slopes, and the proximity to stream channels.

Ground-based equipment would be operating on slopes with a gradient of generally less than 35 percent. The slope limitations for each unit were determined based on soil erosion hazard rating, topography, and proximity to streams. There should be minimal alteration of drainage patterns, because runoff would be dispersed by implementation of effective erosion control structures on roads, skid trails, and landings. The harvest operation as proposed should have little direct effects on soil productivity, water quality and/or quantity or flow regime (Litschert and MacDonald 2009).

The potential indirect effects of the harvest operation includes increased risk of erosion due to isolated removal of soil cover and increased compaction resulting in greater overland flow caused by reduction in infiltration and soil water storage. The ground-based harvest operation has the potential to indirectly affect hydrology and water quality by increasing water yields, peak flows, and the timing of runoff by compacting forest soil and decreasing transpiration. The amount of cover removed should not increase the risk of erosion. Maintaining slash on skid trails and implementing effective erosion control structures will reduce erosion from compacted skid trails. The harvest operation as proposed should result in a minimal increase in the risk of erosion. The treatment prescriptions as proposed would not remove the amount of basal area necessary to generate increases in water yield or peak flow. The hydrologic effects in areas treated with the primary prescription are expected to be minimal. The effects of compaction on water yield should be minimal when management requirements are followed. Maintenance of effective ground cover in the harvest areas would be distributed over the landscape and decrease overland flow of water. Grass, shrubs, and herbaceous ground cover would quickly establish or reoccupy harvested areas. Remaining canopy cover and expected revegetation would aid in reestablishing infiltration rates. Roots of residual and newly established vegetation would hold soil masses together and provide for erosion control.

Cable harvesting equipment will be used on 2 different units on slopes above 35 percent for a total of 249.5 acres. In these units trees will be felled and bunched with a low ground pressure, tracked feller buncher or hand felled and limbed. Both of these methods result in minimal ground disturbance, as the tracked machine is low ground pressure and turning in minimized on steep slopes.

Bunched trees will be whole tree yarded by cable. Hand felled trees will be limbed on the ground, then just the logs will be cable yarded. Cable yarding has minimal impact on the ground as the trees are suspended by one end and the yarding corridor is narrow. Past monitoring of cable yarding has shown that this method results in minimal ground disturbance, and sufficient ground cover is maintained on the unit.

Construction of 2.7 miles of temporary roads are included in the proposed action. The direct and indirect effects of constructing new, temporary roads would be the removal of the topsoil layer and compaction of the road surface. This could increase and redistribute surface drainage and has the potential to increase erosion and sediment delivery to streams downhill of the road. New road cuts have the potential to affect hydrologic function by disrupting and increasing surface drainage by interrupting the shallow subsurface water flow. The temporary roads would be closed and rehabilitated following completion of harvest activities. This would include subsoiling to minimize compaction, reshaping to facilitate drainage and closure to eliminate further use. These treatments would minimize the impact and facilitate revegetation of the road surface.

3.3.2 Fuels Treatments, including: removal of non-commercial trees by whole-tree yarding to the landing, piling (by hand or grapple with tracked equipment) and burning, mastication of shrubs, small trees and slash, and under burning

Erosion, sediment and water quality

Yarding of non-commercial trees and slash will occur as part of the harvest and removal of insect infested trees operation and effects as such are considered in the discussion above.

Piling of fuels will occur by hand on all or portions of all harvest units. This activity has no impact on watershed conditions as existing ground cover of fine (needles, leaves, twigs) material is maintained. Grapple piling using low ground pressure tracked equipment may occur on up to 25 percent or 614 acres of harvest units. This activity will result in minimal disturbance due to the low ground pressure machine and the fuels are picked up and placed in piles, not pushed. As with the hand piling, existing fine material is maintained on site. Jackpot piling may also occur on up to 25 percent of the harvest units. This will occur where localized pockets of dead trees are piled in place to be burned. Jackpot piling will be done with a tracked feller buncher and effects will be similar to grapple piling with low ground pressure tracked equipment.

Pile burning of fuels will occur on all or portions of all harvest units. Management requirements will protect water quality by keeping piles 100 feet away from perennial and intermittent streams and 25 feet from ephemerals. Studies in the Lake Tahoe Basin show this is sufficient to protect water quality (Hubbert, et al. 2015).

Mastication will be done using a low ground pressure track laying machine on 118.3 acres in unit SP-13. Masticated material will be left on site. All treatments will follow the management requirements listed above. The most relevant will keep mechanical equipment on slopes under 35 percent. This treatment will add cover and organic material to the ground. The low ground pressure machine creates very little disturbance. Impacts from this treatment will be minimal to none.

Underburning will be done as a final treatment on all units for a total of 2737 acres. This will occur 2 or more years after the harvest. All treatments will follow the management requirements discussed above. The most relevant will maintain effective ground cover and keep direct ignition out of the riparian buffers.

This treatment will maintain effective cover, thereby having minimal impact on erosion and water quality. It will also reduce the potential for high intensity fire in the future, thus further protecting the treated area from erosion. High intensity fires often remove all ground cover and such areas often experience extremely high rates of soil erosion for a few years following the burn (MacDonald and Robichaud. 2008).

3.3.3 Treat compacted soil

Erosion, sediment and water quality

Compact soil will be treated on approximately 9 miles (13 acres) of non-system roads and trails, landings, main skid trails and temporary roads with equipment such as a winged sub-soiler or other tilling device to a depth of 12 to 18 inches. This treatment will improve watershed condition by restoring porosity in compacted soil, thus allowing natural rates of infiltration on these areas. Compacted soil has low infiltration and rain or snow melt on these soils runs off on the surface rather than soaking into the soil. This runoff is often routed into nearby ditches or stream channels and then flows off the unit. Decompacting these soils will allow this water to infiltrate into the soil. This water is then stored in the soil, resulting in higher soil moisture which is critical for vegetation growth, especially drought stressed trees susceptible to insect damage. Water not stored in the soil recharges the local groundwater table, which supplies water to local streams during dry, low flow periods of late summer and fall.

3.3.4 Maintaining and Repairing existing roads

Erosion, sediment and water quality

Project activities would require approximately 20 miles of road maintenance and repair. This may include: roadside brushing, reconditioning and installation of drainage structures such as dips, water bars, and roadside ditches, culvert cleaning, surface grading, hazard tree felling, and potential spot rocking. It is well documented that road related erosion is a primary source of accelerated erosion in forests throughout the western United States (Kattleman 1996). Road erosion rates are typically much greater than hillslope erosion rates and are highly variable, dependent on factors such as percent hillslope, location on slope, parent material, and years since construction or maintenance (Reid and Dunne 1984).

The proposed repairs would both increase and reduce sources of erosion and sediment delivered to the stream system. Grading road surfaces and clearing ditches loosens and exposes bare ground, temporarily increasing sediment erosion (Coe 2006). Opening and using previously closed roads will also increase erosion during project activities (Reid and Dunne 1984). However, unmaintained roads can also be a major erosion problem. Drainage features such as cross drains or culverts on unmaintained roads often plug with debris and fail. This can lead to concentration of flow on the road surface, causing significant erosion of the road prism and damage to the infrastructure. These erosion features are often permanent and chronic sources of erosion. Repair of this damage is more difficult and costly than periodic maintenance.

Near stream soil disturbance

These road repair activities would have little direct or indirect effects on riparian and aquatic resources when management requirements and BMPs are implemented. The resulting repair work of identified roads would have direct and indirect benefits to the stream system by reducing erosion and sediment sources coming from the road system, reducing the hydrological connectivity of the existing road system, and improving the road effects on downstream beneficial uses.

3.3.5 Reforestation and Site Preparation

Erosion, sediment and water quality

In areas of concentrated mortality, reforestation will be done using a combination of site preparation, plant and release treatments. Site preparation would include tilling the top soil, as needed, to remove brush and other competing vegetation to facilitate the planting effort. Tilling will be done on up to 60 acres. This treatment will follow the management requirements discussed above. The most relevant will keep mechanical equipment on slopes under 30 percent and out of the riparian buffers. Also effective ground cover will be maintained at or above 50 percent across the treated units. The tilling will be confined to small areas where brush is too thick for successful planting. Impacts of this action will be minimal. Undisturbed ground between the tilled areas will act as a buffer to capture any localized soil erosion. Recent monitoring of reforestation treatments on National Forests in California has shown that following the management requirements above and associated BMPs to protect water quality are 98 percent effective and have resulted in no adverse impacts (USDA Forest Service 2013b).

Near stream soil disturbance

The proposed activities would follow project management requirements, which would limit operations in riparian buffers while meeting the Forest Plan soil cover requirements and should not lead to the direct or indirect effect of near stream soil disturbance.

3.5 CUMULATIVE WATERSHED EFFECTS ANALYSIS

Ground-disturbing activities can cause both direct and indirect effects that persist through time. The cumulative result of all these effects is the potential to adversely affect downstream beneficial uses of the water. Cumulative watershed effects (CWE) analysis may reveal that even though the proposed activities themselves may not be sufficient to substantially impact the watershed, when analyzed in connection with past and future activities on all ownerships, they may become a cause for concern.

The Pacific Southwest Region (R-5) of the Forest Service has developed a standardized cumulative watershed effects (CWE) analysis (FSH 2509.22) that serves as a surrogate method for determining the risk of delivering excess sediment to streams. This cumulative watershed effects analysis compares (a) the existing level of land disturbance across all ownerships within a watershed with (b) an estimate of the upper limit of watershed tolerance to disturbance, referred to as the Threshold of Concern (TOC). The level of land disturbance is measured using Equivalent Roaded Acres (ERAs), whereby all disturbances are equated to an acre of road. The cumulative watershed effects analysis then recovers these disturbances over some period of time following a specified recovery curve. Using this analysis, the calculated ERA of a watershed is compared to the TOC to provide an assessment of the potential for cumulative watershed effects. The TOC is not an exact point at which effects will occur. It is an indicator that a watershed is more susceptible to impacts. As ERA approaches or exceeds the TOC, additional measures are employed to protect and monitor watershed conditions.

The Tahoe National Forest has developed a standard method for determining watershed TOC values. Each watershed is assessed for its ability to withstand erosional processes and handle sediment delivery to stream channels. The assessment is based on climatological, geologic and soils information, on-the-ground surveys of the stream channels and upland areas; and the experience and knowledge of current and previous TNF hydrologists.

ERA coefficients and recovery rates have been developed based on soil monitoring results, literature reviews, and consultation with other hydrologists.

3.5.1 Cumulative Effects of the Proposed Action

The CWE calculations for the project area are shown below in the table 4. These calculations are based on the assumption that mechanical thinning and removal of insect infected trees will be accomplished in 2017 and underburning will occur in 2020. Results for 2017 and 2020 are shown. The table shows that the existing condition in project area drainages is below the threshold of concern. Also, the treatments proposed by this project will not add a significant amount of ERA to most drainages. In the Upper North Shirttail drainage, the percent ERA will increase from below 3 to over 8 in 2017 and nearly 11 in 2020. This is still below the TOC. Therefore, the proposed action will likely not lead to cumulative effects.

The project activities will be monitored following the best management practices evaluation program (BMPEP) in accordance with the soil and water quality handbook (USDA Forest Service 2000, 2002, and 2011). This will entail randomly selected and targeted monitoring of the project with the primary objective of confirming that appropriate measures were implemented and determining whether those measures are effective in controlling erosion and protecting water quality.

The Forest Service has been monitoring the implementation and effectiveness of BMPs for many years (USDA Forest Service 2013). The results of this monitoring show that, overall, the BMP program is adequately protecting water quality. Monitoring conducted between 2008 and 2010 showed that BMPs were implemented 91 percent of the time, and 80 percent of implemented BMPs were rated as effective.

It should also be noted that the ERA results in table 4 are based on the maximum footprint of the proposed actions. This in effect shows the most conservative result. Detailed design and on the ground layout of the treatments is ongoing. This work is guided by the BMPs and management requirements. Once finalized, the footprint of the units is likely to be considerably less than what was used to calculate the ERAs. This actual footprint is difficult to model at this stage of the project. However, it is a piece of information that needs to be considered as it provides some important context for the analysis of CWEs associated with this project.

Table 4. Cumulative Watershed Effects Analysis Results

Drainage Name	Acres	% TOC	2017 Preproject % ERA	2017 Postproject % ERA	2020 Postproject % ERA
Upper North Shirttail Canyon 18020128060101	5912	13	2.62	8.46	10.71
Lower North Shirttail Canyon 18020128060102	6053	13	4.38	4.55	6.10
Volcano Canyon 18020128050301	5060	14	4.29	4.49	4.87
Peavine Creek 18020128040302	5485	12	2.50	3.30	4.37
NFMF American – El Dorado Canyon 18020128040304	4977	14	2.92	2.95	2.84

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